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An Improved Trawl Door Hook-up System

MIT Sea Grant
College Program

Massachusetts
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MITSG 79-22
September 1979

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Report Number 79-22
Index Number 77-322-Nhl
September 1979

ACKNOWLEDGEMENTS

This project was funded by the M.I.T. Sea Grant College Program which is supported by the Office of Sea Grant in the National Oceanic and Atmospheric Administration through grant number 04-6-158-4407. The support of the M.I.T. Department of Mechanical Engineering is acknowledged, in particular the facilities and personnel of the Materials Processing Laboratory.

The authors wish to thank Joe Novello of Gloucester, owner of the "Vincie-N" and Peter Favazza, also of Gloucester, owner of the "Everfree" for their cooperation in testing and evaluating this hardware.

AUTHORS

Clifford A. Goudey developed the hook-up system while a graduate assistant in MIT's Department of Ocean Engineering. Currently he is serving as a consulting fisheries engineer to the Extension Sea Grant Advisory Service.

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INTRODUCTION

Few tasks aboard a fishing trawler are as hazardous as door hook-up. Careful coordination between the hook-up man and the winch operator is required. Heavy seas, slippery decks and aging or faulty equipment can contribute, but misjudgement is the usual cause of injuries. The problem has been recognized for many years, and at the request of local fishing industry representatives, this research was undertaken to find a solution. The primary goal was the reduction of human risk involved in the operation. Consideration was given to possible reduction in time required for the door hook-up operation, as well as the effect any development might have on other aspects of trawler productivity.

A thorough examination of existing local gear and methods was done. Related techniques from other domestic and foreign fisheries were researched, with particular regard to recent developments aimed at improved safety. Though research was found which addressed the specific problem of trawl door hook-up, no practical solution existed in our opinion.

Two designs were evolved, one fully automated and the other a partly manual hook-up operation. For reasons of cost and practicality, only the latter and simpler design was developed and tested. The research findings and sea trial results follow.

EXISTING DOOR HOOK-UP TECHNIQUES

The drawing in Figure 1 represents a typical arrangement of trawl net and doors. The outward angle of the trawl doors provides the required horizontal spreading force as the system is pulled through the water along the sea bottom. The vertical openings of the net is produced by the buoyant floats placed along the headline as shown. In bottom trawling, the distance between the door and net wing has a strong effect on the amount of fish caught. Trawl doors can effectively herd fish into the path of the oncoming net; therefore, by lengthening the bridles the distance between the two doors can be two to three times greater than the distance between the net wings.

The two tow cables lead from the trawl doors up to the trawler. On a side trawler the cables are hauled over wide sheaved blocks or bollards located fore and aft on one side of the vessel. In stern trawlers the cables lead to bollards at the stern, on the port and starbord quarter. In both types of trawler the bollard is supported above the rail by a gallows frame.

At the completion of a tow, the trawl is hauled in until the doors reach the gallows frame. At this point, unless the vessel is equipped with an additional net hauling winch or net drum, the doors must be secured

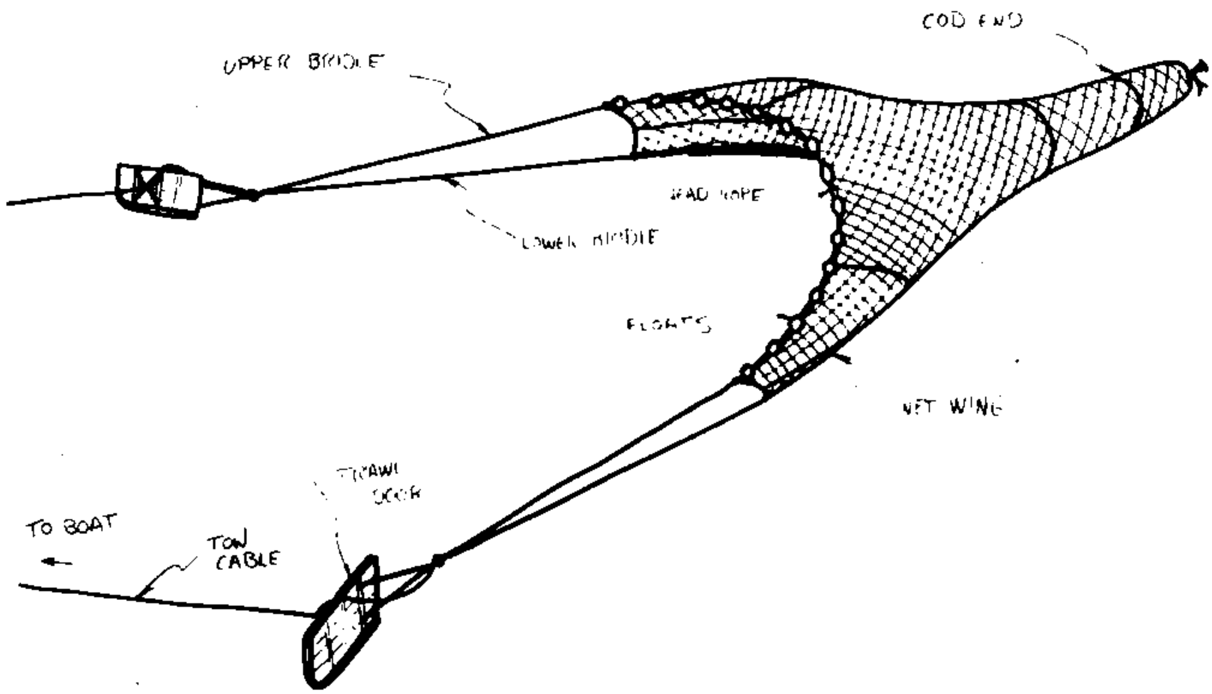

Figure 1: Typical trawl system configuration.

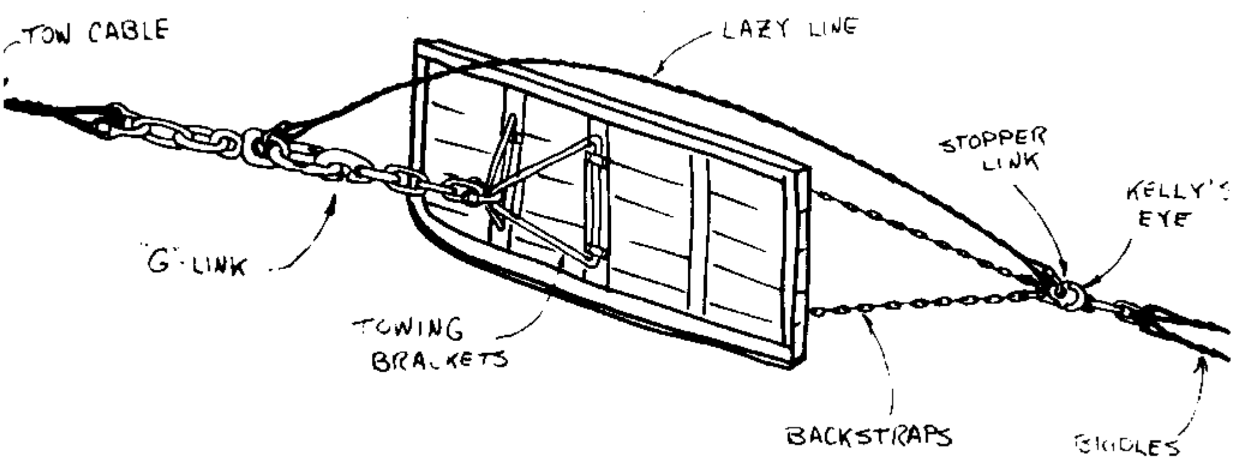

Figure 2: Trawl door and rigging.

at the rail, uncoupled from the main tow cable, and hauling resumed until the net wings reach the bollards. The rigging and "G" link couplers of a typical trawl door are shown in Figure 2. This securing and uncoupling is the door hook-up operation and is performed by one of the crew stationed at each gallows. The door is held in position by the winch brake while the hook-up man secures it with a chain and hook, called a dog chain. An extreme roll or surge of the vessel can cause higher tension in the cable resulting in brake slippage. This sudden movement of the door can cause injury. Even in calm weather, some winches, (or winch operators) have a tendency to slip if the friction brake is not applied before the drum is fully disengaged. In this situation, a crewman attempting hook-up can be caught by the door. Similar dangers are present during the setting of the doors.

RELATED RESEARCH

Recent efforts have been made to improve the safety and efficiency of trawlers. Although much of this work has been done abroad, and aimed at large factory trawlers,[1-2] a recent development by the M.I.T. Sea Grant Program resulted in the introduction of an improved towing block for the U.S. fleet. The new block provides speed and safety during blocking up of the towing warps.[3]

The specific problem of trawl door hook-up has been addressed in two investigations, one in Russia and the other in the United States. A Russian device has been reported which automates the entire process of trawl door hook-up and detachment from the hauling cable with no pause of the winch until the dan leno, a device that separates the upper and lower bridles, reaches the gallows block.[4-5] The rig consists of a bell-mouthed housing attached to the hanging bollards. These housings are set at the same angle at which the cables lead during the approach of the doors. The doors are attached to the cable by a cylindrical shaped mechanism which fits into the bell housing and is secured there by catches, which pivot and simultaneously release the cable to allow further hauling.

The device is rugged, simple and a reasonable size. The part connected to the door reportedly weighs between 14 and 15 pounds. Trials of the device were reportedly successful, but there is no evidence of its adoption by the Soviet fleet, probably because the system does have some major drawbacks. The cylindrical mechanism at the door has an inside clearance that is sufficient for only a single cable. This precludes the use of a bridle to achieve vertical height at the wings. It also means abandoning the conventional method of taking the strain of the net to the back of the doors by a Kelly eye and chain bridle. This would severely reduce the stability of a conventional door, resulting in improper control on the bottom, and possible fouling in the propeller during setting. Either of these factors may account for the general lack of acceptance of the system.

The second study was done at Northeastern University for the National Marine Fisheries Service at Woods Hole, Massachusetts.[6] The automatic device proposed is similar in concept to the Russian development except that the inside clearance is enlarged to allow passage of shackles and bridles. The entire mechanism is designed to handle loads of 80,000 pounds; however, further development was abandoned after testing. The mechanism did not operate properly, it was far too heavy and cumbersome to be used with existing trawl gear or traditional side trawling vessels, and it was considered too intricate to operate reliably in a fishing environment. Finally, the cost of its production promised to be prohibitively high.

Both of these earlier automatic door hook-up innovations mechanized the entire hook-up operation. Though the NMFS device with further development could have been made operational, the Russian hardware is far superior in design. Work was therefore done to design a similar, durable, compact system which would perform the required tasks and be compatible with the gear currently used abroad local trawlers. In addition, any development must be economically justifiable to be adopted commercially.

IMPROVED SYSTEM DESIGN

Compatibility in regard to breaking strengths is important for any new piece of gear. Anticipated loads on various parts of the trawl system can be determined analytically or by actual measurement. These loads depend mostly on net size, vessel size, and horsepower. However, significant increases in loads can occur during heavy seas, from underwater obstructions, or because of operator misjudgement. The continual attack on all parts of the gear by the corrosive environment and the abrasion of parts when they come in contact with the seabed require frequent monitoring to ensure that sufficient strength remains.

During the tow, the winch brake is set just enough to stop the paying out of cable so that if the trawl comes upon an obstruction or becomes choked with fish or trash, the cables would surge out rather than part. Most gear failure occurs during the process of freeing a hang-up. The skipper will usually reverse the vessel's course and pull the trawl off the obstruction. If this maneuver fails, further attempts are made by pulling in other directions. When all else fails, the warps will simply be hauled in until the trawl breaks free or the trawl system breaks, and in the process all or part of the gear can be lost.

It is important, therefore, that the load-bearing parts of the trawl be well designed and based on the pulling power of the winch. Since weight is an advantage in keeping the trawl fishing on the bottom, and since wear occurs, the temptation to over design gear in the lower part of the trawl system is understandable. Doing this can be dangerous as it often leads to a crew being forced to cut the cables at the water's edge and lose the entire trawl, because nothing would part.

To reduce gear losses resulting from hang-ups, a fisherman should use components that provide for a logical order of failure, such as the following:

1. Deck fairleads, gallows frames, hanging bollards — <u>Strongest</u>
2. Winch brake capacity
3. Main trawl cable
4. Door and towing brackets
5. Main trawl cable attachment to door
6. Idler, back straps, bridles
7. Footrope
8. Other net parts — <u>Weakest</u>

The towing block is not used in the process of freeing a hung net and need only be strong enough to withstand its component of the load required to surge the winch while towing, since the block is released before hauling commences. Also excused from this failure sequence is the method used to secure the door in position while landing the catch. The maximum load imposed on this gear is the total weight of the doors, net and catch, and the resistance of the net and catch due to the drift of the vessel. Ample allowance must be made for increases due to sea condition and motion of the vessel.

AUTOMATIC SYSTEM

Two systems were conceived which would provide safer door hook-up operations by introducing automated mechanisms to all or part of the existing system. A fully automated system was designed which, like the NMFS and Russian devices, secures and uncouples the trawl door without a pause in the hauling sequence. The conceptual design, pictured in Figure 3, incorporates sufficient internal clearance to allow the passage of trawl shackles and multiple or chain bridles. Figure 4 shows the cross section and operation of the mechanism. With the exception of the three catch levers, most parts would not require machined surfaces or precise tolerances. The design shown is composed mainly of concentric parts made from standard pipe sections.

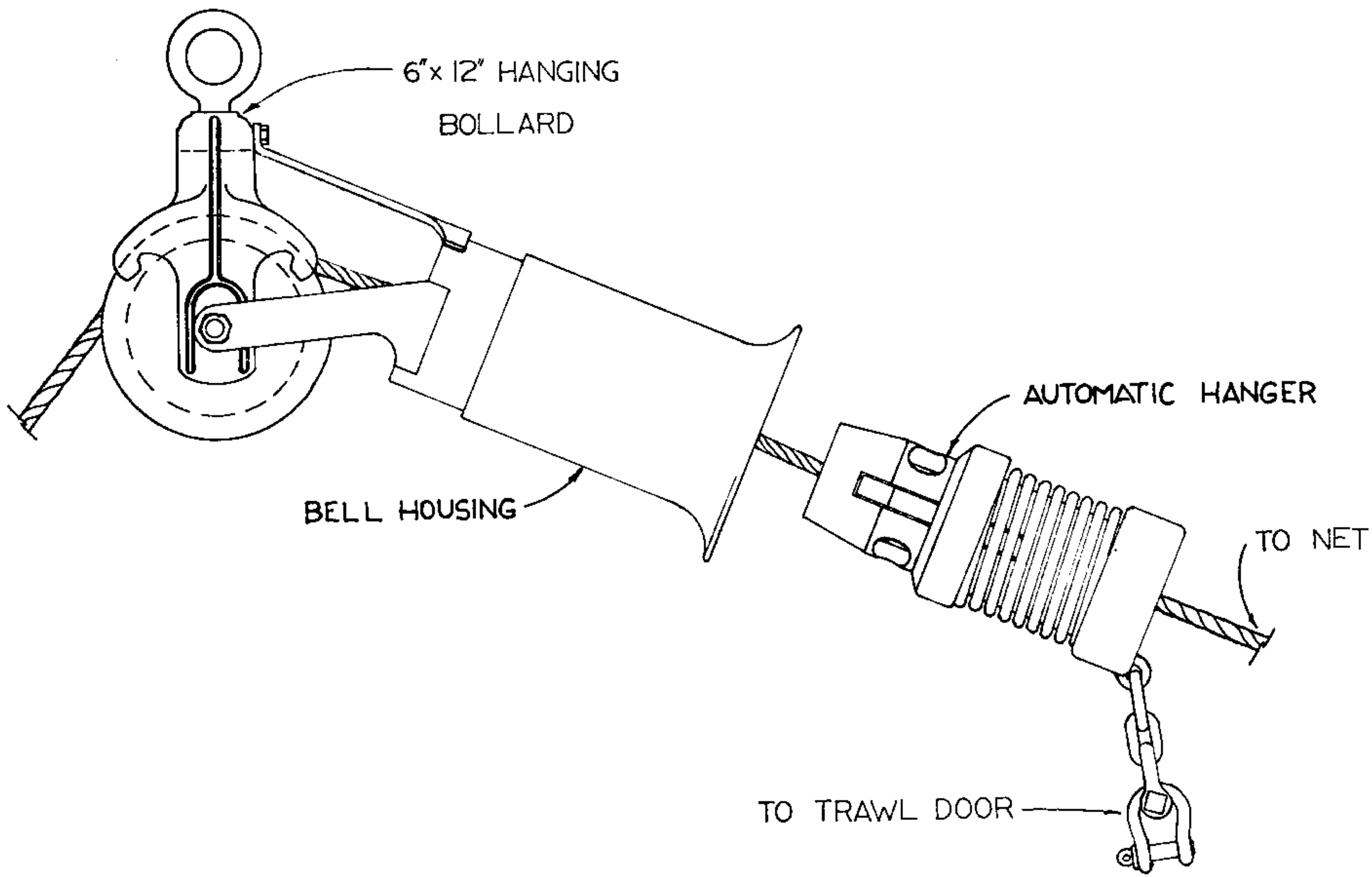

Figure 3: Automatic door hook-up system design

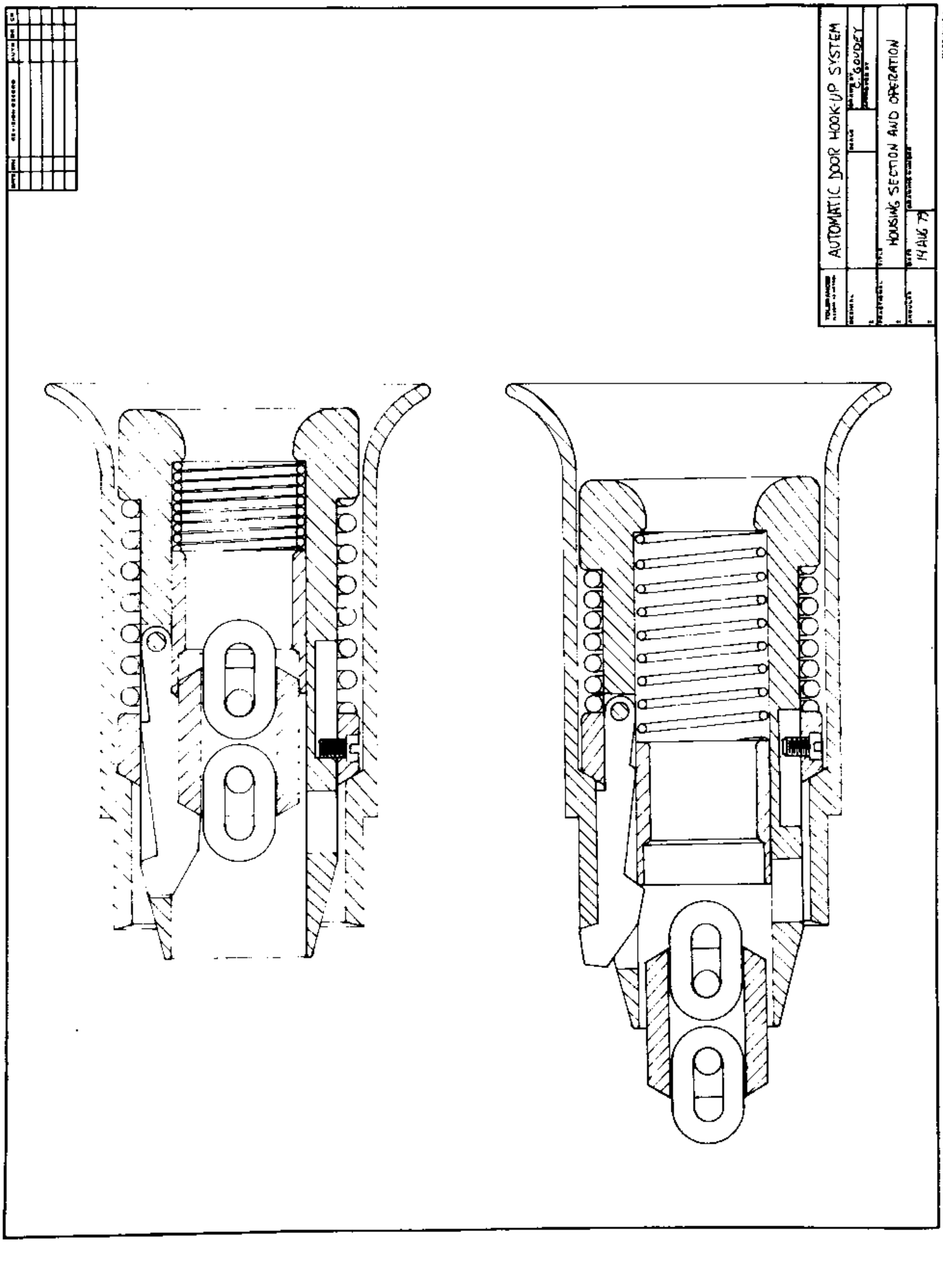

Figure 4: Cross section and operation of hook-up mechanism.

A two dimensional plastic model of the proposed mechanism was constructed to allow for a better evaluation of the concept. The model performed as anticipated, allowing a continuous pull on the boss with the hanger becoming securely latched in the two dimensional bell housing. Paying out was equally as effective with no pause required. However, this operation required a continual pull outward by the net until the hanger released. This presented a limitation in that it could not be incorporated in the existing door arrangement without some modification. Presently the net is payed out until the strain is taken by the Kelley eye and backstraps, and the lazy line then goes slack. This would leave no force to operate the hanger mechanism.

At this point several options are available. One could add a means of forcing the lazy line and boss into the hanger until unlatching was complete. Alternately, rigging could be arranged so a tension is maintained on the lazy line by careful adjustment of its length. The backstraps would then take the strain just as the boss released the hangar. This arrangement seemed plagued with adjustment problems although a lazy line with a controlled stretch might allow more consistent operation.

The cost of such a system was estimated to be between $600 and $2000 per boat. This cost and the relative complexity compared to the existing system prompted further consideration of a semi-automatic system.

SEMI-AUTOMATIC SYSTEM

A device was sought which would automate part of the hook-up procedure. Figure 5 is a sketch of a system which will automatically secure the door, leaving the uncoupling to be done manually. This eliminates the most dangerous part of the hook-up operation, requiring intervention by the crew only after the door is securely hung.

The design shown is adapted for installation on a standard 6" x 12" hanging bollard. The hanger pivots on extensions of the main shaft. It

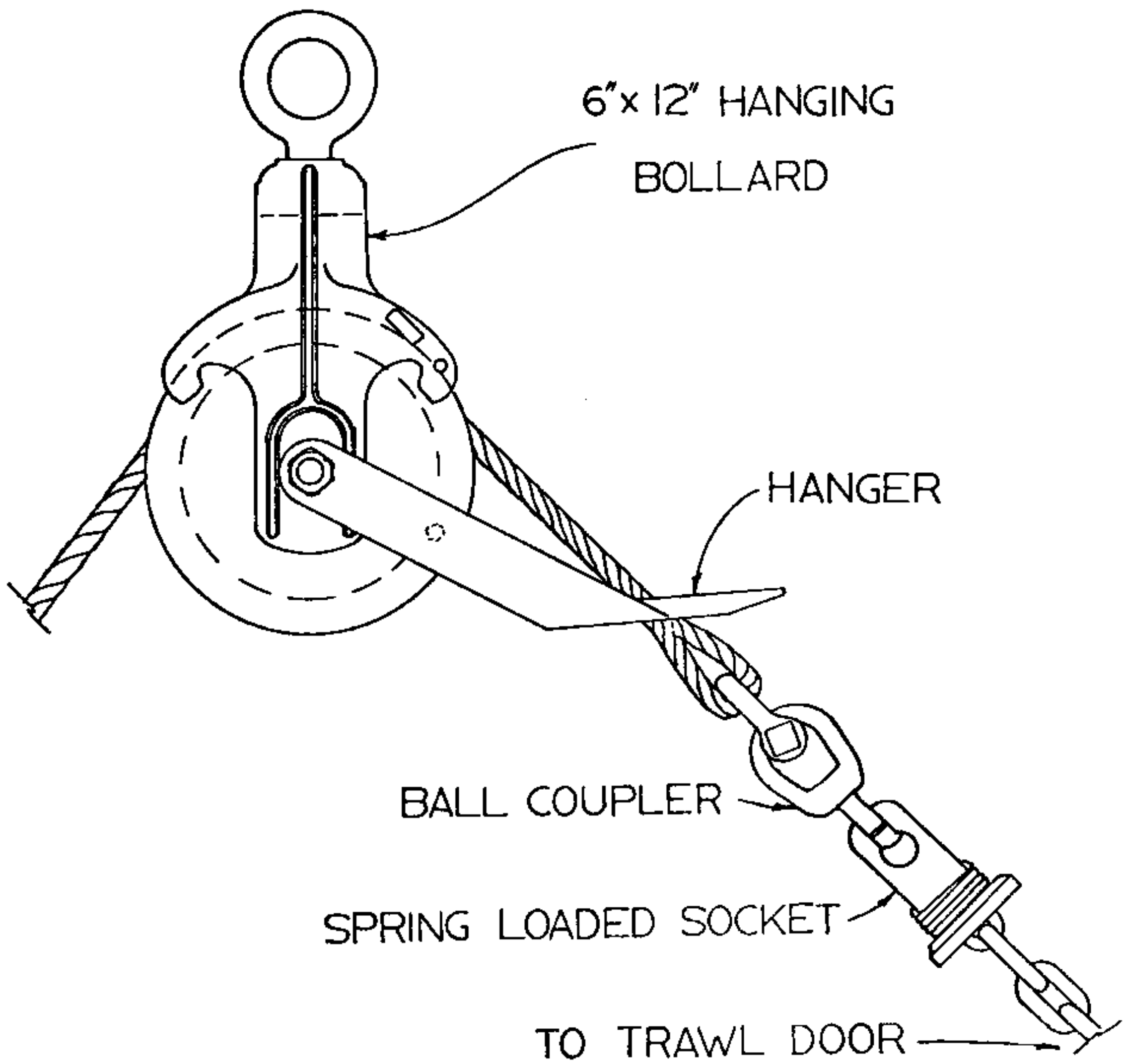

Figure 5: Semi-automatic door hook-up system.

can be pivoted up and held by a detent when not in use, being lowered at the approach of the doors. When lowered, the hanger rests on a cable until the coupler passes under, at which time the winch is slackened and the coupler pulls back into the "U"-shaped slot and the door is hung. This is shown in Figure 6. The coupler shown is designed for easy one-handed operation and is detailed in sectional view in Figure 7. Its design prevents accidental uncoupling should the cable become slack while fishing, but when suspended by the hanger the spring is compressed and separation is easy.

A coupler of this type has additional benefits over the present "G" links. A coupler provides swiveling capability, eliminating the need for the main trawl cable swivel. Present swivels have problems becoming jammed with sand and seizing up. They also fail because internal wear is difficult to detect. The uncoupling swivel eliminates both these problems because it is separated after each tow, allowing the removal of any grit and the inspection of any wear.

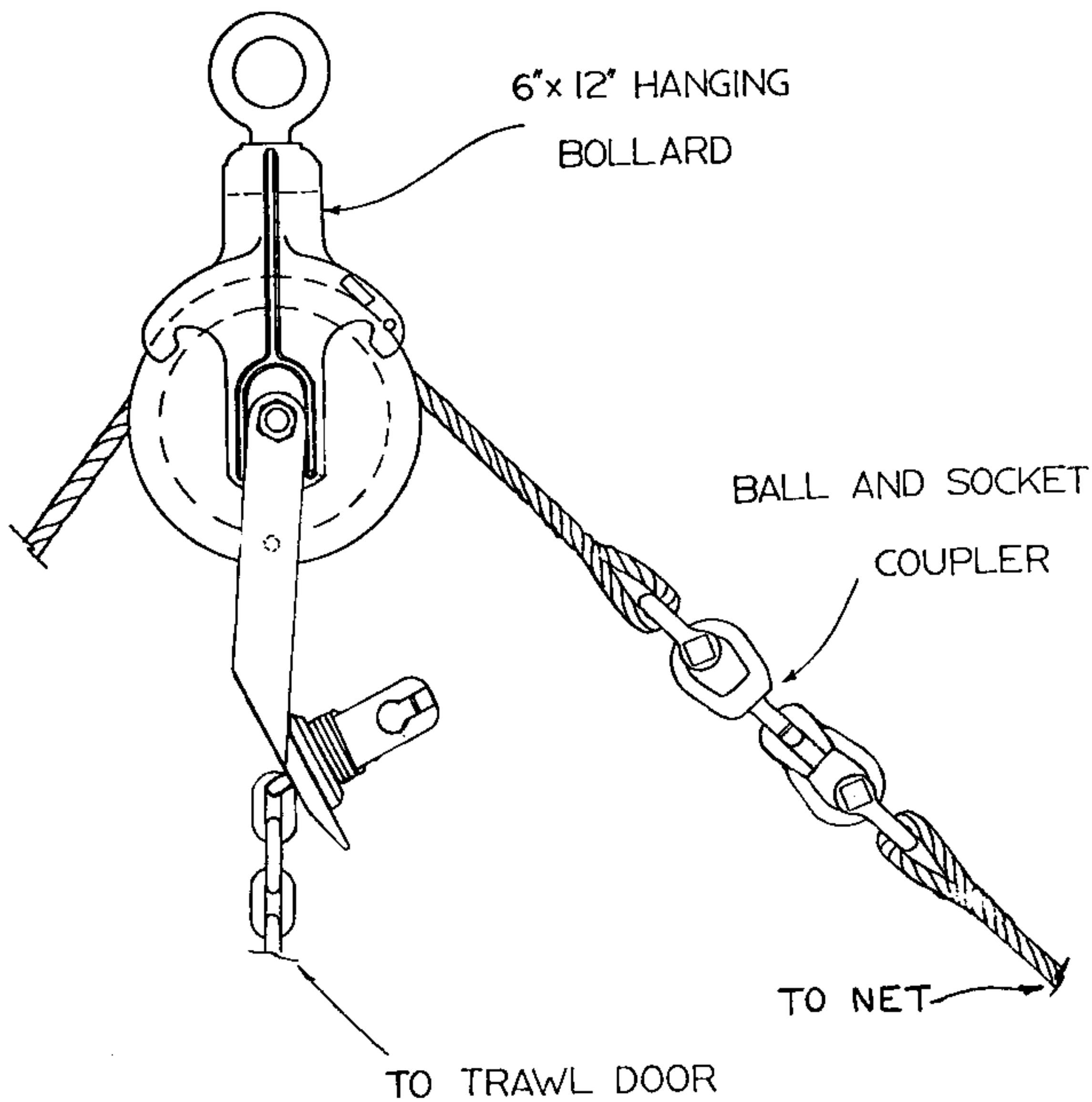

Figure 6: System after door is secured.

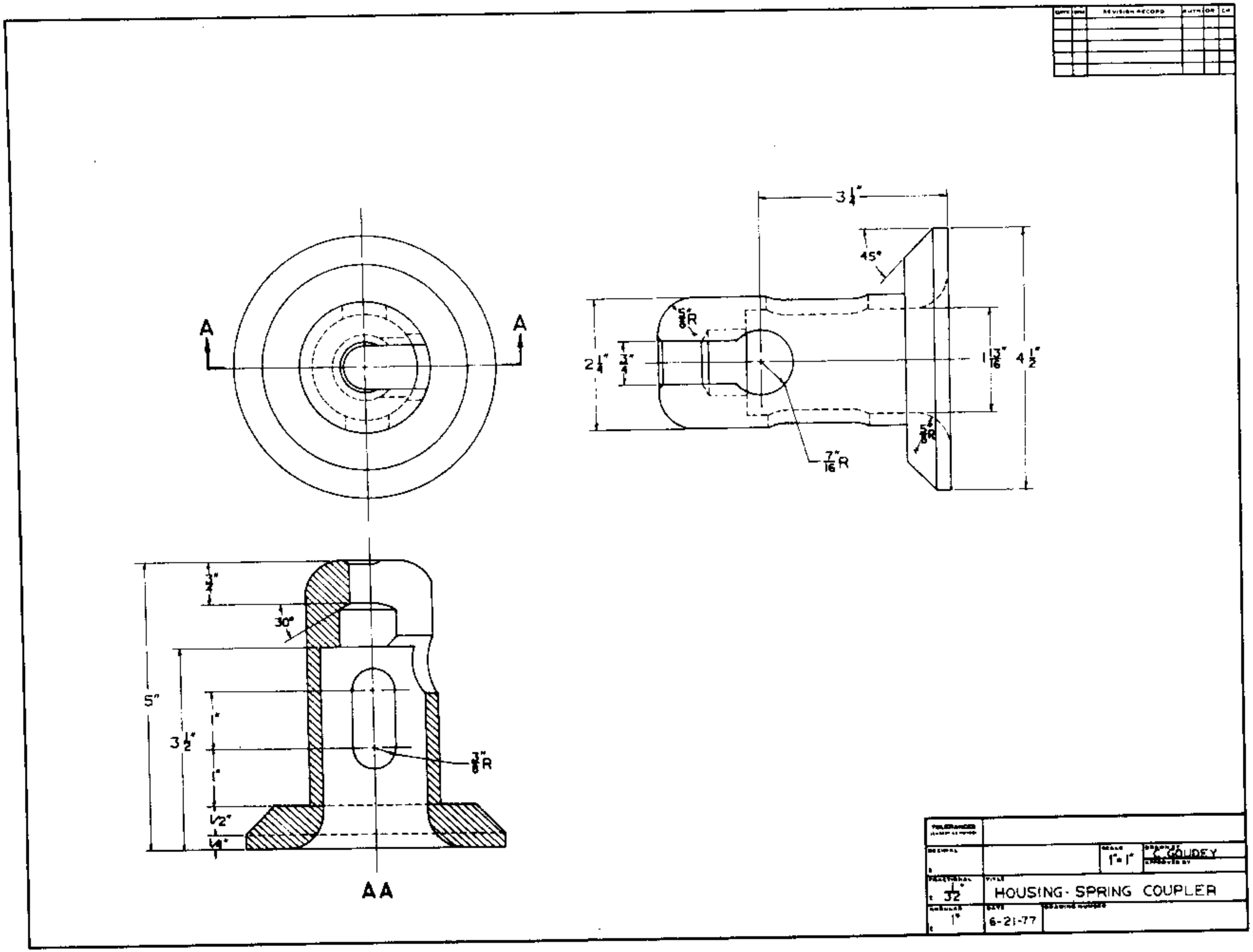

Figure 7: Cross section of spring-loaded socket coupler.

The basic trawl system would remain unchanged. The lazy line would have a similar coupling socket without the spring-loaded features. While towing, the lazy line would be connected to a male coupler located conveniently at the door brackets.

The hanger could easily be used with the present "G" link hardware by locating a hook-up link with a circular flange in the position ahead of the door. This scheme might appear more attractive to those fishermen who are satisfied with the uncoupling characteristics of the "G" links. This scheme is shown in Figure 8.

A prototype system was constructed for testing purposes. Its size was to be appropriate for the mid-size range of New England trawlers. Cable diameters would range from 5/8" to 3/4" with breaking strengths of approximately 18 to 25 tons respectively. The component sizes were determined by calculations and scaling of model tensile tests. The coupler compenents were sized to be of comparable strength to the 3/4" cable. The hanger bracket was designed for loads of 10 tons, far in excess of any anticipated loads.

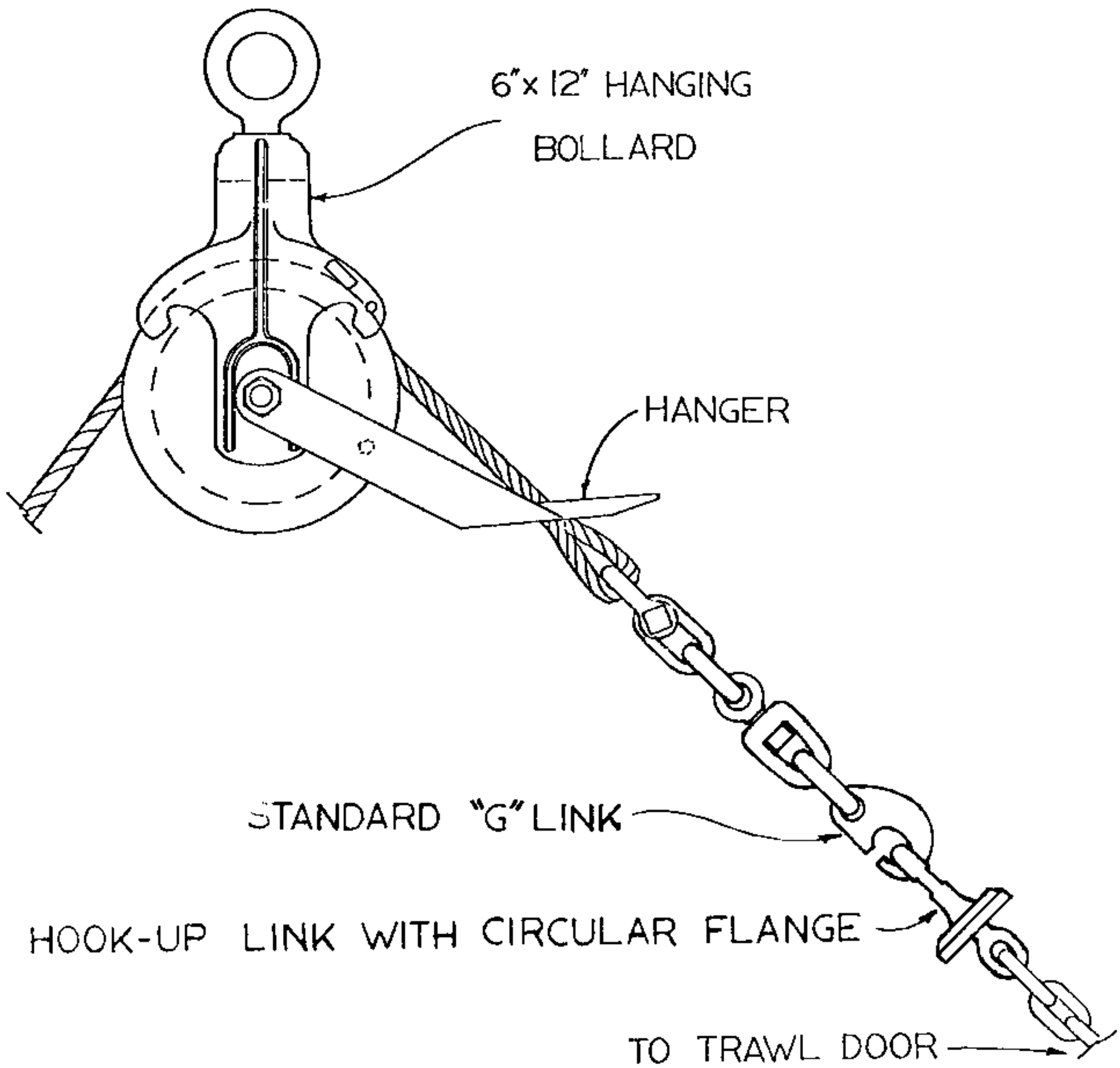

Figure 8: Modified "G"-link couplers.

The prototype was subjected to laboratory tests to determine the best angle for the "U" plate. The test set up is shown in Figure 9 with the door weight being simulated by a lead block. From these tests the ease of operation and inherent safety were evident.

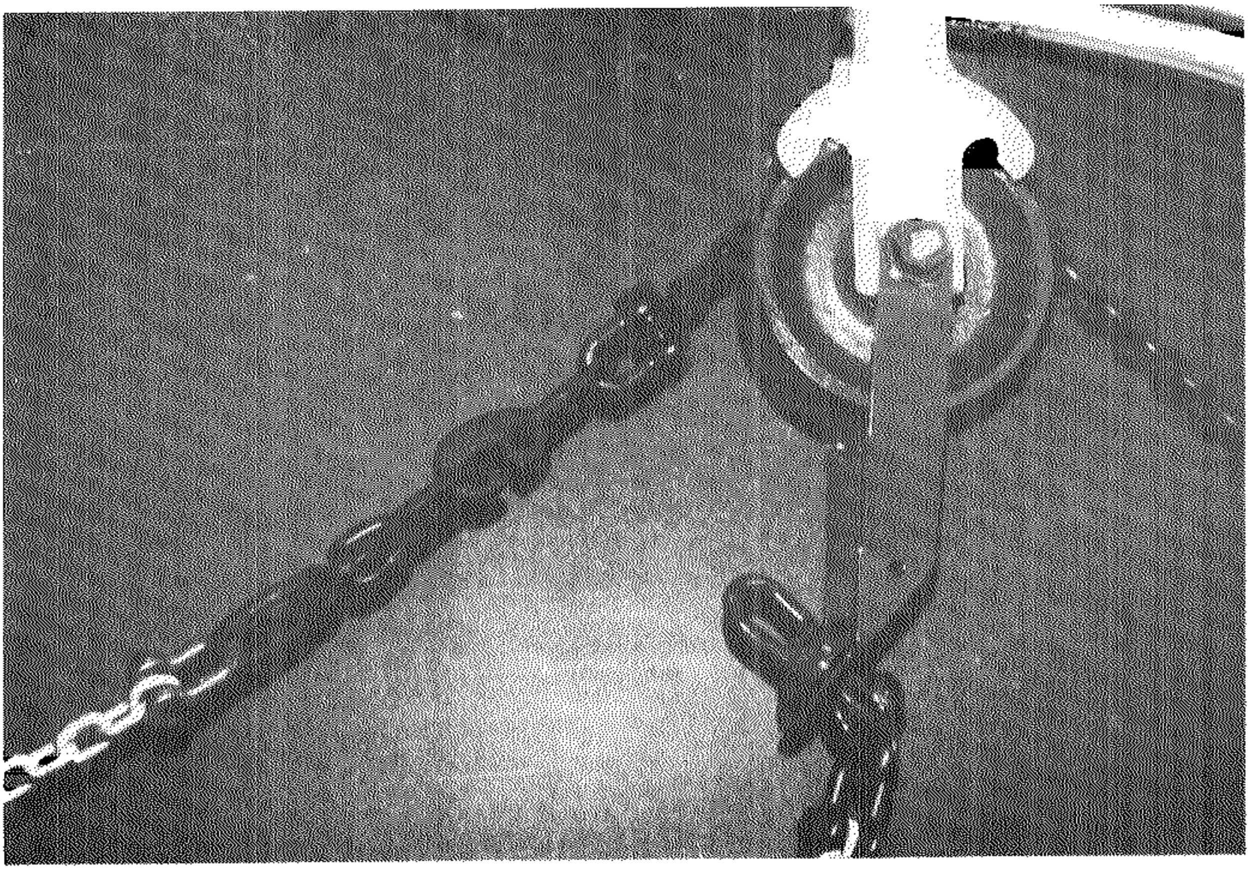

Figure 9: Laboratory tests of hook-up system.

COMMERCIAL TESTING

Tests of the system aboard a Gloucester side trawler, the "Vincie N" indicated again that the simplicity of the system lead to much safer operation. The system was installed on the after gallows as shown in Figure 10 and the

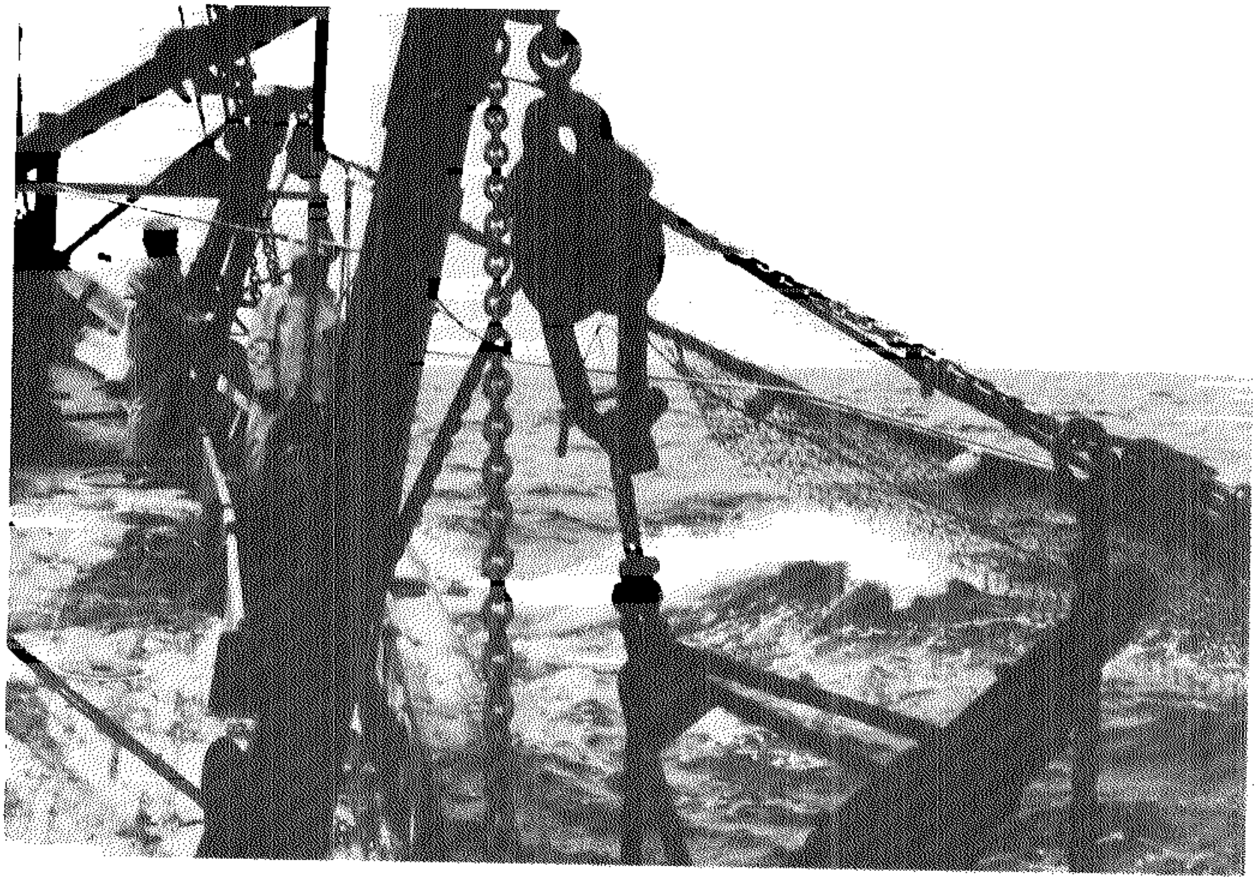

Figure 10: Testing aboard the trawler "Vincie-N".

conventional hook-up techniques were kept on the forward gallows. During these tests no significant time advantage was noted since the conventional hook-up is effective in calm weather. The safety feature provided the contrast, with the door being securely hung before the crewmen approach the after gallows.

Some possible improvements were identified by this testing. Coupling could be hastened if the tolerances between the ball and socket coupler were greater. To keep the hung door high above the water, the hanger arm could be shortened as could the length of chain between the coupler and door brackets.

A smaller prototype system was constructed to be compatible with gear aboard inshore draggers and was installed aboard the "Everfree" out of Gloucester (Figure 11). This system incorporated the standard "G"-links as couplings and was sized for 4" x 8" hanging bollards. The vessel's captain found the system well-adapted to his two-man operation. Door hook-up was made possible without the need for stationing a crewman at each gallows. This savings in time is especially significant on day boats, such as "Everfree", where one crew member handles both port and starboard hook-up.

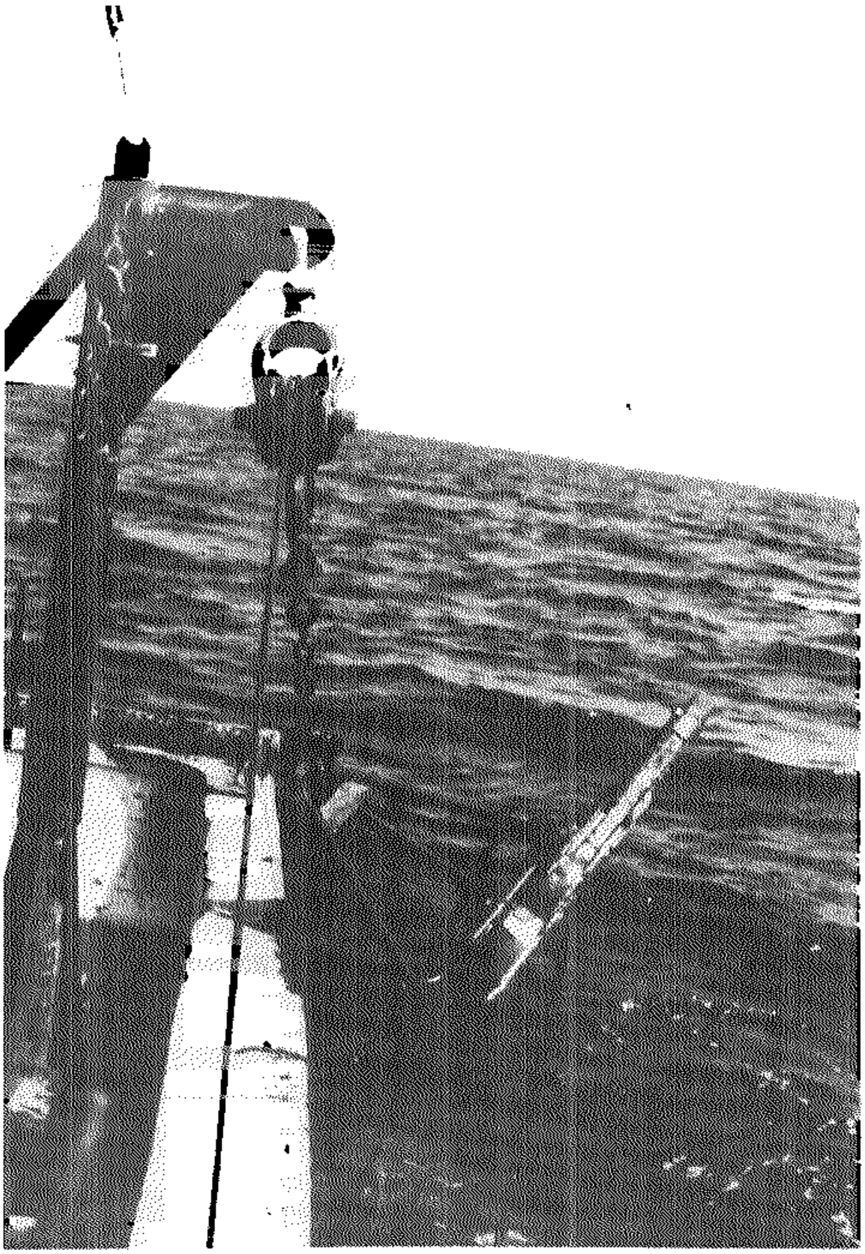

Figure 11: Smaller system installed aboard trawler "Everfree".

CONTINUED DEVELOPMENT

Based on the successful trawler testing and the obvious simplicity of the semi-automatic system, efforts are underway to promote its commercial development and adoption by the fishing industry, where appropriate. Other handling and rigging applications where the system could be usefully adapted will be considered. U.S. patent number 4,119,300 has been issued on the system and its components.

The low cost and ease of manufacture of the system, especially when "G" link couplers are used, lends itself to fabrication by the boatowner. Most of the components of the system being used aboard the "Everfree" were made by the vessel's captain Peter Favazza. The only exception was the lengthened, case-hardened shaft which was provided by the M.I.T. Sea Grant Program.

The larger prototype system, based on 6" x 12" bollards, will be used to further test and introduce the gear within the local fleet. Any fisherman interested in seeing the system in operation, trying the prototype system aboard his vessel, or fabricating a system for himself, or any manufacturer interested in the hardware, should contact the inventor:

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APPENDIX

The following drawings are provided to show the construction details of some of the prototype hardware. Figure A1 shows the components from which the hanger used on the "Everfree" was fabricated. Its installation was pictured earlier in Figure 11. The material is mild steel and the two arms are welded to the sides of the U-plate.

New shafts were machined from 1 1/4" diameter high strength hexhead bolts as shown in Figure A2. The shoulder portion was case hardened and ground to provide an inner race for the sheave roller bearings. Also shown are the bronze bushings and washers upon which the hanger pivots. These parts are designed for use with a 4" x 8" block common to the industry and manufactured by Hathaway Machinery Co. of Fairhaven, Massachusetts. Other types of blocks can also be adapted to receive the hanger.

Figure A3 shows the components comprising the ball and socket couplers. The cold formed bail is welded to the machined socket. The ball and shaft is machined from an alloy 7/8" fine thread bolt. This is installed in a standard eye nut and locked in place by a tack weld. These components are companions to the spring loaded socket pictured earlier in Figure 7.

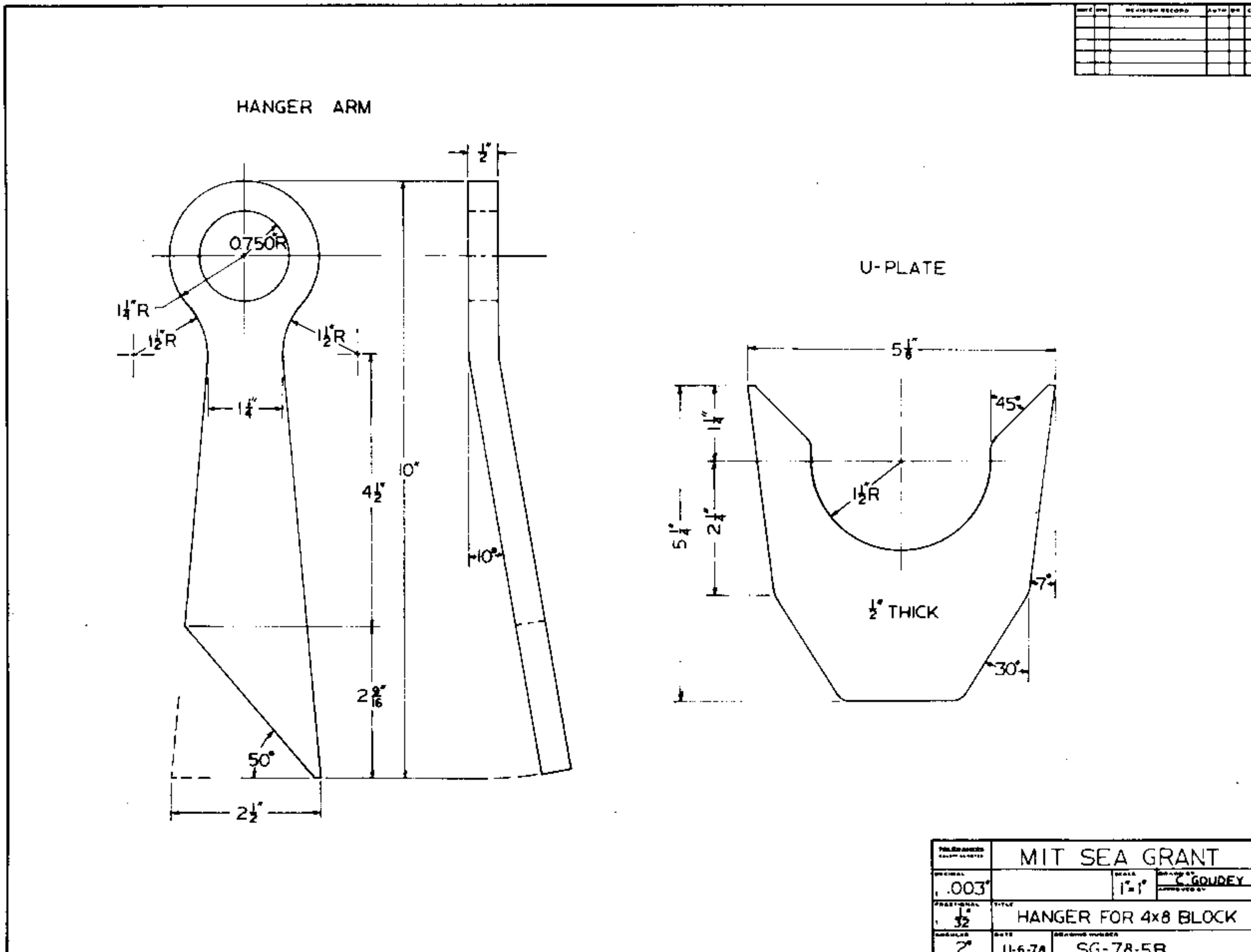

Figure 1A: Hanger for a 4" x 8" Block.

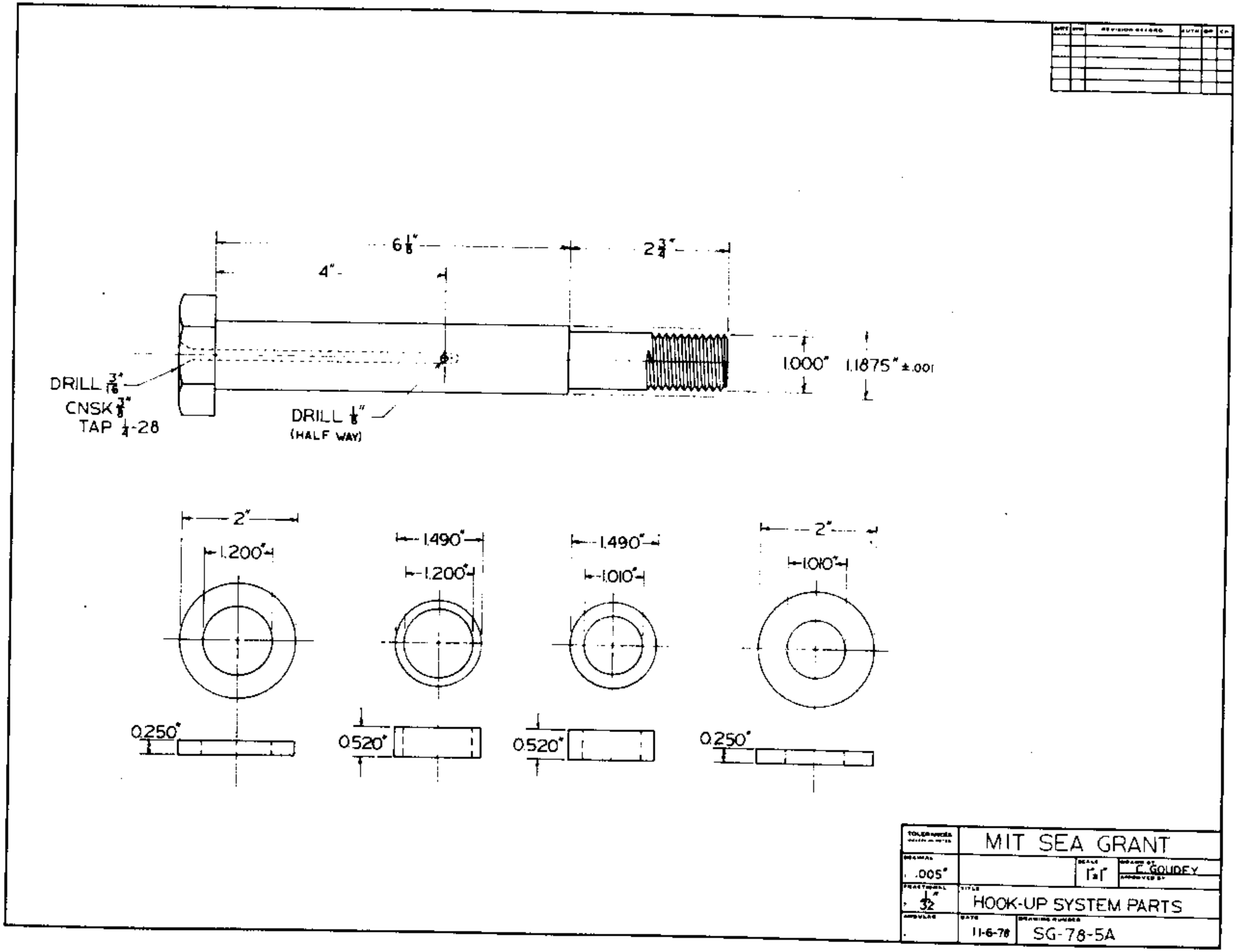

Figure A2 Hardened shaft and bushings for 4" x 8" block.

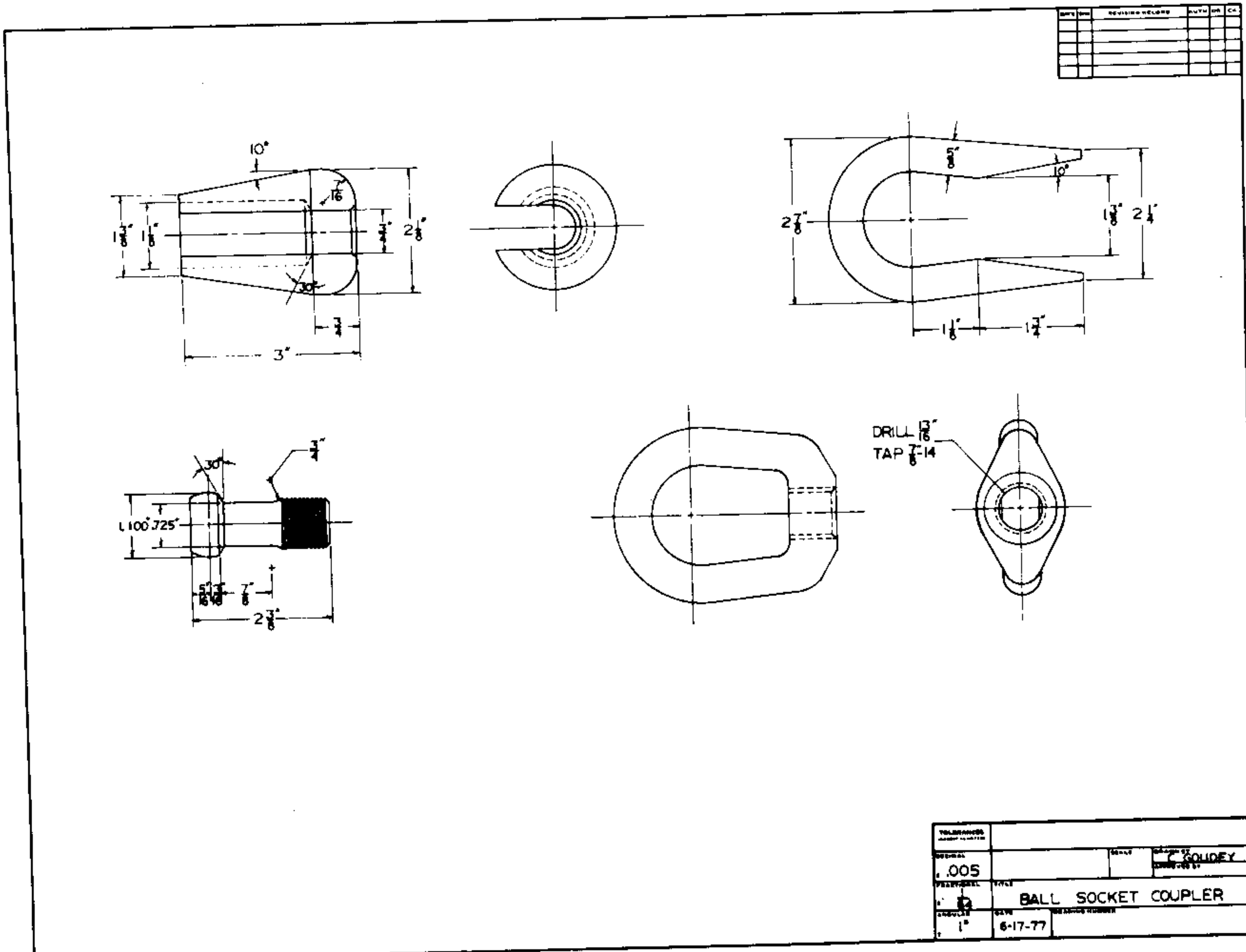

Figure A3: Components for medium sized ball and socket couplers.